the steady state equation becomes:

$$\nabla^2 n - \frac{n}{L^2} + \frac{3q_T}{\lambda_t v} = 0 \qquad (7\text{-}3)$$

For a point source of slow neutrons ($q_T = 0$ except at $r = 0$ where q_T is a delta function), the equation reduces to:

$$\nabla^2 n - (n/L^2) = 0 \qquad (7\text{-}4)$$

The solution is spherically symmetrical, so equation (7-4) reduces to the radial equation:

$$\frac{1}{r}\frac{d}{dr}\left(r^2 \frac{dn}{dr}\right) - \frac{n}{L^2} = 0 \qquad (7\text{-}5)$$

Let $u = nr$. The equation becomes $u'' - (u/L^2) = 0$ where $u'' = d^2u/dr^2$. Solutions are $u = \exp(\pm r/L)$. The boundary condition that $n \to 0$ as $r \to \infty$ eliminates the positive exponential, so the solution is:

$$n = A\frac{e^{-r/L}}{r}$$

The constant A can be evaluated by considering a small sphere enclosing the source at the origin. The neutron current, equation (6-20) of Chapter VI, is $-D\nabla n = -Ddn/dr = -DAe^{-r/L}[-1/(Lr) - 1/r^2]$. Multiplying this by the area of the sphere $4\pi r^2$ and letting $r \to 0$ gives $4\pi DA$. This is the source strength Q. Thus A is $Q/(4\pi D)$ or $3Q/(4\pi\lambda_t v)$. The complete solution to (7-3) for a point source of Q slow neutrons per unit time is:

$$n = \frac{3Q}{4\pi\lambda_t v}\left(\frac{e^{-r/L}}{r}\right) \qquad (7\text{-}6)$$

The solution may be checked by substitution in equation (7-5).

The point source solution is particularly important since any source can be represented by a proper assembly of point sources, and the corresponding solution is the superposition of these point source solutions.

To solve this equation for a *point source of fast neutrons* we set up an integral over a distribution of thermal neutron point sources all over space that arise from the slowing down of the fast neutrons (see Figure 40). Now we can find the density of slow neutrons at a distance r from the point source of fast neutrons as follows. In any volume element dV, a distance $\vec{\rho}$ from the point source of fast neutrons, there are q_T dV thermal neutrons per second being produced by the slowing down process where q_T [see equation (6-28)] is:

$$q_T = \frac{Q}{(4\pi\tau)^{3/2}} e^{-\rho^2/4\tau}$$

with τ = age for thermal neutrons,

Q = fast neutron source strength (neutrons/second).

The volume element dV is expressed in spherical coordinates, $dV = \rho^2 d\rho \sin\theta\, d\theta\, d\phi$, and the polar axis ($\theta = 0$) is taken to pass through the point at which we are finding the thermal neutron